

Temperature history of the bacterial domain of life based on molecular and geologic records.

Eric Gaucher

Historically, the evolutionary study of protein function involves identifying the chemical and physical signatures produced in a test tube or model organism. Alternatively, the nature of these behaviors can be detailed through analyses of extinct genes. This is possible because an organism's survival depends on its ability to interact with its environment, which is ultimately determined by the organism's genome. Thus, genes behave as dynamic fossils: recording ancient events, while enabling adaptation within contemporary environments. The last common ancestor of the bacterial lineage, and the environmental conditions in which it lived, have been a focus of my research. This work utilizes laboratory and computational techniques to explore the likely chemistry of the ancient organism by inferring its genetic structure from the genes of extant organisms. The reconstructions of ancestral genes define the field of paleobiochemistry, and provide a greater understanding of protein behavior, in terms of both its origin and our ability to manipulate it. In particular, I am interested in: 1) resurrecting ancestral sequences in anticipation of correlating the genomic and geologic records, 2) elucidating the mechanisms of molecular adaptations, including protein translational machinery, 3) introducing ancestral genes into modern organisms containing a genetic knockout of a gene of interest to understand adaptive landscapes (experimental evolution). The proposed work will resurrect proteins from ancient bacteria to constrain the temperature at which bacteria that gave rise to modern bacteria lived. The work will exploit elongation factors (EFs), proteins that are involved in translation. EFs have several virtues that make them especially suitable for this work. Their sequences are found in all bacteria, eukaryotes, and archaea. They are highly conserved, making the reconstructions of ancestral character states relatively reliable. Their temperature-activity profiles display, in modern bacteria, optima near the optimum growth temperature of the host bacteria. They have other activities, including cytoskeleton binding and oligomerization, which make them relevant to the emergence of the cytoskeleton in eukaryotes. We shall reconstruct and study these properties from prokaryotes throughout the Archean and Proterozoic (3500 to 543 Mya). Inferring the temperature history of the dominant domains of life on Earth places a limit on the type of environment these organisms inhabited and types of metabolic processes (biochemistry) utilized by early life, and provides direction in the search for life on other planets. These studies will also show how proteins adapt to various temperatures through replacements of amino acids, and how the genomic record captures these adaptations.